SEMICONDUCTOR DEVICE AND FABRICATION METHOD FOR THE SAME

TECHNICAL FIELD

[0001] The present disclosure relates to a semiconductor device and a fabrication method for the same, and more particularly to a semiconductor device having a trench gate structure and a fabrication method for the same.

BACKGROUND ART

[0002] In recent years, semiconductor devices having a trench gate structure have attracted attention. While a channel is formed on the surface of a semiconductor layer in semiconductor devices having a planar gate structure, a channel region is formed on the side of a trench provided in a semiconductor layer in the semiconductor devices having the trench gate structure. The trench gate structure semiconductor devices are therefore more expected to achieve miniaturization and reduction in ON resistance than the planar gate structure semiconductor devices. For this reason, in the field of power devices, in particular, development of trench gate structure semiconductor devices is underway.

[0003] The trench gate structure semiconductor devices, which are free from the limitation on miniaturization caused by the junction FET (JFET) effect, have an advantage that a fine trench can be formed to permit reduction in ON resistance and switching loss. However, a problem arises that the aspect ratio of a fine trench is large, making it difficult to embed a gate electrode in such a trench. Also, since the cross-sectional area of the gate electrode decreases, the gate resistance will increase. To prevent or reduce the increase in gate resistance, it is being examined to form a gate electrode in a T shape to extend the gate electrode over the periphery of the trench (see Patent Document 1, for example).

[0004] Also, in the trench gate structure semiconductor devices, it is important to form a suitable gate insulating film inside the trench. An electric field is concentrated on the bottom of the trench, where the field strength is higher than in any other portion. Therefore, there is the possibility that a breakdown due to a dielectric breakdown of the gate insulating film may occur at the bottom of the trench.

[0005] If the gate insulating film is thickened as a whole to increase the dielectric breakdown field, the threshold voltage at switching will increase. Therefore, a method of forming a thicker gate insulating film on the bottom of the trench using a difference in plane direction between the side and bottom surfaces of the trench is being examined (see Patent Document 2, for example). Also being examined is a method where a mask is formed on the side of the trench during formation of the gate insulating film to form a thick gate insulating film on the bottom of the trench while preventing or reducing formation of an oxide film on the side of the trench (see Patent Document 3, for example).

CITATION LIST

Patent Document

[0006] PATENT DOCUMENT 1: Japanese Patent Publication No. 2007-281512

[0007] PATENT DOCUMENT 2: Japanese Patent Publication No. H07-326755

[0008] PATENT DOCUMENT 3: Japanese Patent Publication No. 2007-242943

SUMMARY OF THE INVENTION

Technical Problem

[0009] However, the conventional trench gate structure semiconductor devices described above have the following problems. First, in the case of controlling the thickness of the gate insulating film using the plane direction of the substrate, a substrate having a special plane direction is necessary, and this increases the fabrication cost. Also, it is not possible to set the film thickness on the side of the trench and that on the bottom thereof to arbitrary values independently.

[0010] In the case of forming a mask on the side of the trench to form a thick gate insulating film only on the bottom of the trench, steps of forming and removing the mask are necessary. This complicates the fabrication process, and increases the fabrication cost and the cycle time.

[0011] In the case of forming a T-shaped gate electrode, it is necessary to form the gate insulating film also on the portion of the semiconductor layer surrounding the trench. If the gate insulating film formed on the periphery of the trench is thin, the gate-source capacitance will increase, causing a delay. In formation of a T-shaped gate electrode, therefore, it is necessary to control not only the thickness of the portions of the gate insulating film on the side and bottom of the trench, but also the thickness of the portion thereof on the periphery of the trench.

[0012] Moreover, if a thick gate insulating film is formed on the periphery of the trench, the trench will become virtually deep, increasing the aspect ratio. This raises a problem of making it difficult to embed the gate electrode in the trench.

[0013] The problems described above occur commonly in silicon semiconductor devices and in semiconductor devices using a wide band-gap semiconductor such as silicon carbide (SiC). The relative permittivity of SiC (9.7 for 4H—SiC) is smaller than that of Si (11.9), and the difference thereof from that of SiO_2 (3.8) is small. Therefore, in a semiconductor device using SiC, a larger electric field is applied to the gate insulating film, causing a larger problem.

[0014] According to an embodiment disclosed in this specification, a semiconductor device is provided where control of the thickness of the gate insulating film inside the trench and on the periphery of the trench is easy and also embedding of the gate electrode into the trench is facilitated.

Solution to the Problem

[0015] One form of the fabrication method for a semiconductor device disclosed in this specification includes the steps of preparing a substrate having a semiconductor layer provided on a principal surface; forming a trench in the semiconductor layer; forming a gate insulating film on a side of the trench, a bottom of the trench, and a periphery of the trench; and forming a conductive film on the gate insulating film to fill the trench and extend on the periphery of the trench. The step of forming a gate insulating film includes a step of forming a first insulating film on the side of the trench and a step of forming a second insulating film on the bottom of the trench and the periphery of the trench using a high-density plasma chemical vapor deposition method, the thickness of portions of the gate insulating film formed on the bottom of the trench and the periphery of the trench being made larger than that of a portion of the gate insulating film formed on the side of the trench. In the step of forming a conductive film, the